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INTRODUCING AND FINDING TRIPOLES: A NEW CLIMATE TELECONNECTION PATTERN

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***Abstract*—Climate teleconnections are the relationships between long distant regions. In this work, we introduce a novel climate teleconnection pattern called tripole. A tripole involves three regions A, B, and C, such that the anomaly time series at region C is more strongly correlated with either addition or subtraction of anomaly time series observed at region A and region B, as compared to that with any of the anomaly time series at region A or B alone.**

I. BACKGROUND

Climate teleconnections are the relationships between long distant regions. Dipoles are one such category of climate teleconnections that have been extensively studied in previous works [1]. They are characterized by a strong negative correlation between the anomaly time series of a climate variable observed at the two distant regions, e.g. NAO, El-Nino oscillation (ENSO). In this work, we introduce a novel climate teleconnection pattern called tripole. A tripole involves three regions A, B, and C, such that the anomaly time series at region C is more strongly correlated with either addition or subtraction of anomaly time series observed at region A and region B, as compared to that with any of the anomaly time series at region A or B alone. A stronger correlation between anomaly time series at C and sum or difference of anomaly time series at A and B (comb correlation) can be a possible outcome of a climate phenomena that can explain the relationship between region C and the two regions, A and B. We also propose a novel algorithm to search these tripoles across the three distant regions in a global dataset.

Tripoles can be categorized based on the correlations between every pair of regions into 1) Negative tripoles, 2) Positive tripoles, and 3) Mixed tripoles. In negative tripoles, all the pairwise correlations between the anomaly time series observed at regions A, B, and C are negative, and the sum of anomaly time series at A and B has a stronger negative correlation with C compared to either of the pairs, A and C or B and C. In positive tripoles, all the pairwise correlations are positive, and the sum of anomaly time series at A and B has a stronger positive correlation with C compared to either of the pairs, A and C or B and C. In mixed tripoles, there are both positive and negative correlations. Region C shows positive correlation with A and negative correlation with B, whereas regions A and B show a strong mutual positive correlation. The difference of anomaly time series at A and B has a stronger positive correlation with that of C compared to either of the pairs, A and C or B and C.

A tripole is interesting only if the correlation with C improves significantly as A and B are combined. Positive tripoles often do not show high improvement in the correlation, and might not be always interesting. On the contrary, a negative tripole is quite intriguing and rare as it involves two negatively correlated regions showing similar relationship with a third region, which ultimately leads to a much stronger negative correlation between C and A+B. Similarly, in a mixed tripole, two positively correlated regions show opposite relationships with a third region, which is rare and results in a much stronger positive correlation between C and A-B.

II. METHOD

In this work, we focus on finding negative and mixed tripoles. Since the climate phenomena that drive any teleconnection typically span over the regions of size of thousands of kilometres, we expect tripoles across regions to be more reliable as opposed to tripoles across individual grid points. In this work, we search for three regions such that their area weighted anomaly time series form a tripole, where a region is defined as the set of spatially contiguous grid points whose anomaly time series are strongly correlated with each other. As the number of combinations of three arbitrary regions is exponential in the number of grid points, a brute-force search is not feasible. Therefore, we developed a new methodology based on shared nearest neighbor (SNN) graph-based approach [2] to find tripoles in climate data. For negative

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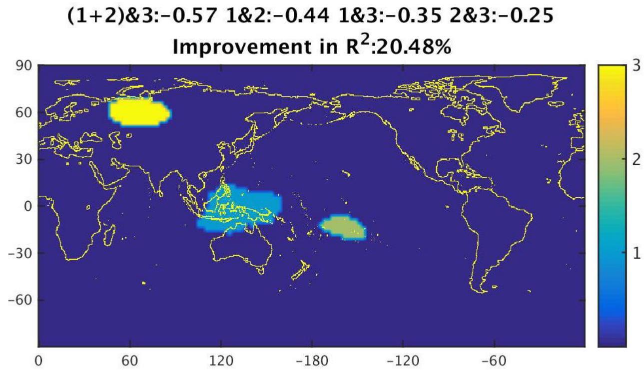

Fig. 1: A negative tripole

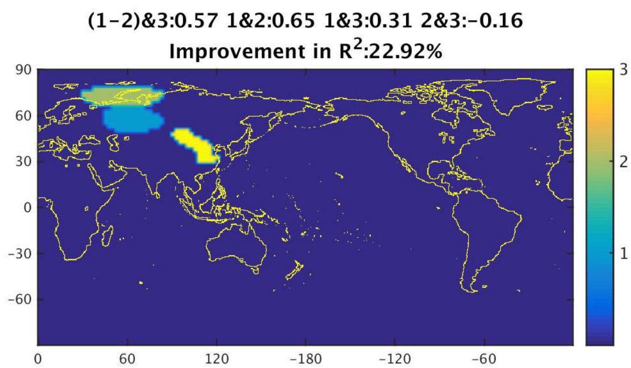

Fig. 2: A mixed tripole

tripoles, our methodology uses an approach similar to [3] to first find all the dipoles and then for each dipole, a third region is searched that shares negative neighbors with both the ends. For searching mixed tripoles, first all the positive teleconnections are found across two non-overlapping regions and then for each teleconnection, a third region is searched that shares positive neighbors with one end and the negative neighbors with the other end.

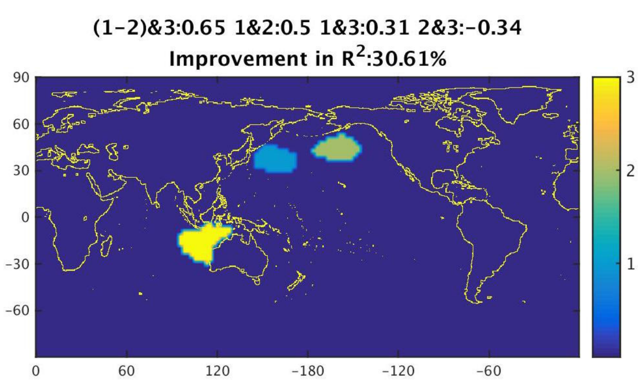

Fig. 3: A mixed tripole

III. Results

We searched for negative and mixed tripoles on DJF-monthly sea level pressure (psl) data for 1979-2011 (2.5 x2.5 degree resolution) provided by the NCEP2 Reanalysis. Figures 1 to 3 show some of the negative and mixed tripoles that we found using our SNN approach. Numbers 1,2, and 3 in the title of each figure represent the blue,green, and yellow regions (also analogous to notations A,B, and C in the previous section) respectively. Figure 1 shows a negative tripole that we found across northwestern Russia and the two ends of ENSO. The tripole indicates a negative correlation of -0.57 between the anomaly time series of northwestern Russia and the sum of the anomaly time series of the two ends of ENSO, as compared to the pairwise correlations with either of the ENSO ends (-0.35,-0.25). ENSO is forced by an anomalous SST pattern between the west Pacific warm pool and the eastern Pacific Ocean. We take monthly time series of mean sea level pressure for the two ends of ENSO (around Darwin, Australia and Tahiti) and add the z-scored area mean values of both regions to describe the background state of ENSO. We find that the background state of ENSO is linked to a pressure pattern over northwestern Russia. We identify a wave train that connects northwestern Russia via central Asia and eastern China to the ENSO region around Darwin, Australia. The link to the ENSO region can be detected in the geopotential height fields around 500 hPa. The tripole was also found to be consistent during the winter months of 1901-1945 (**1+2**,**3**) = -0.57) and 1946-1978 (correlation(**1+2**,**3**) = -0.52) observed in HadSLP2 (Hadley Centre Sea Level Pressure Version 2) data.

Acknowledgments

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